IPPD Through RDS

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Presentation Outline

- What is IPPD?
- What is IPPD Through RDS?
- What is SBA?
- What is an Advanced Engineering Environment?
- What is a Virtual Stochastic Life Cycle Design Environment?
- Summary and Conclusions

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What is IPPD?

- *Integrated Product/Process Development (IPPD)* is a management methodology that incorporates a systematic approach to the *early integration* and concurrent application of all the disciplines that play a part throughout a system's life cycle (Technology for Affordability: A Report on the Activities of the Working Groups to the Industry Affordability Executive Committee, The National Center for Advanced Technologies (NCAT), January 1994)
- IPPD evolved out of the commercial sector's assessment of what it took to be world class competitive
- The DoD has required IPPD and the use of IPTs where practical throughout the DoD Acquisition Process for Major Systems (DoD 5000.2R)
- Conduct of IPPD requires Product/Process Simulation using Probabilistic Approaches

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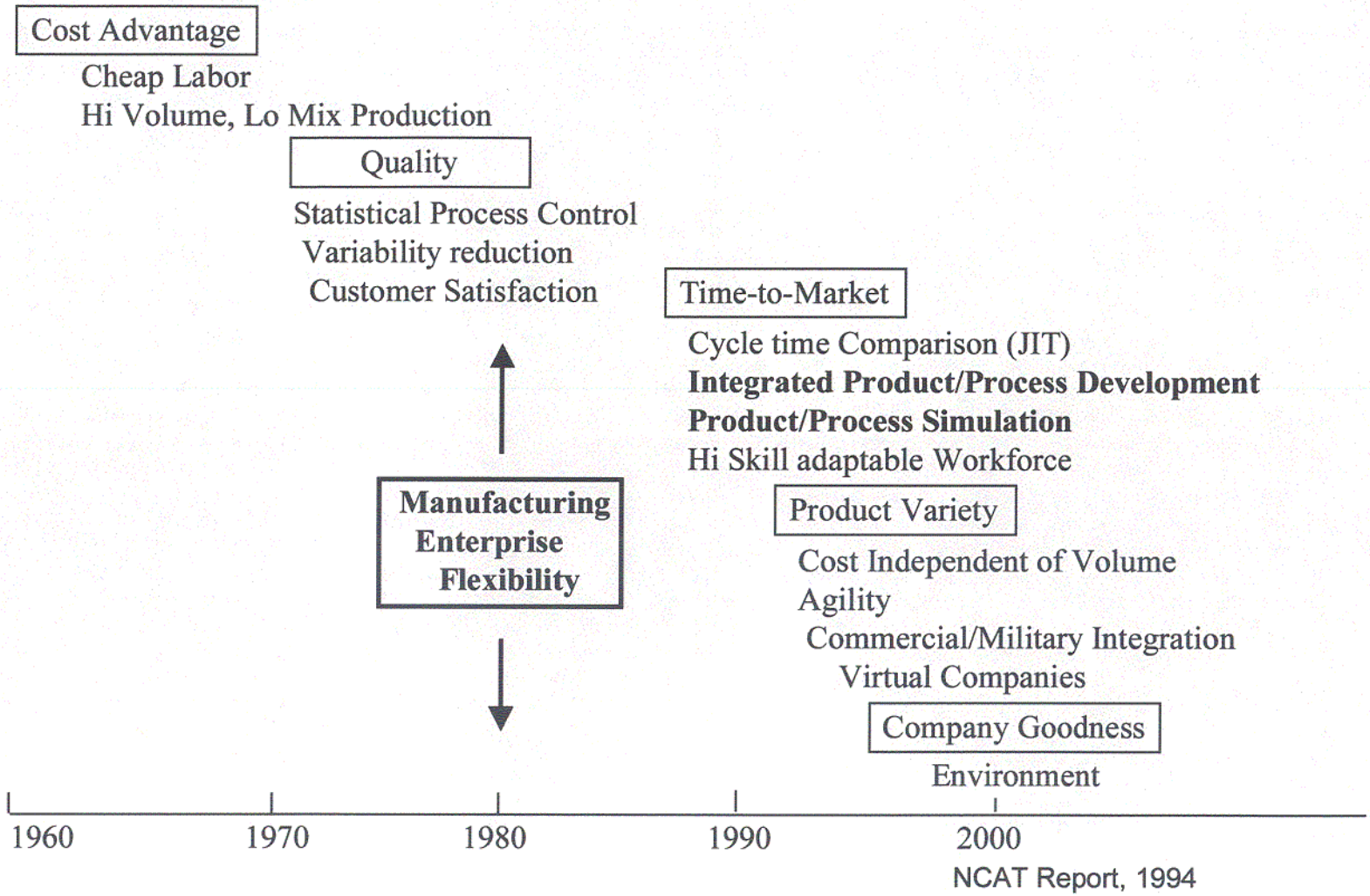
Quality Revolution - Where Competition is Today



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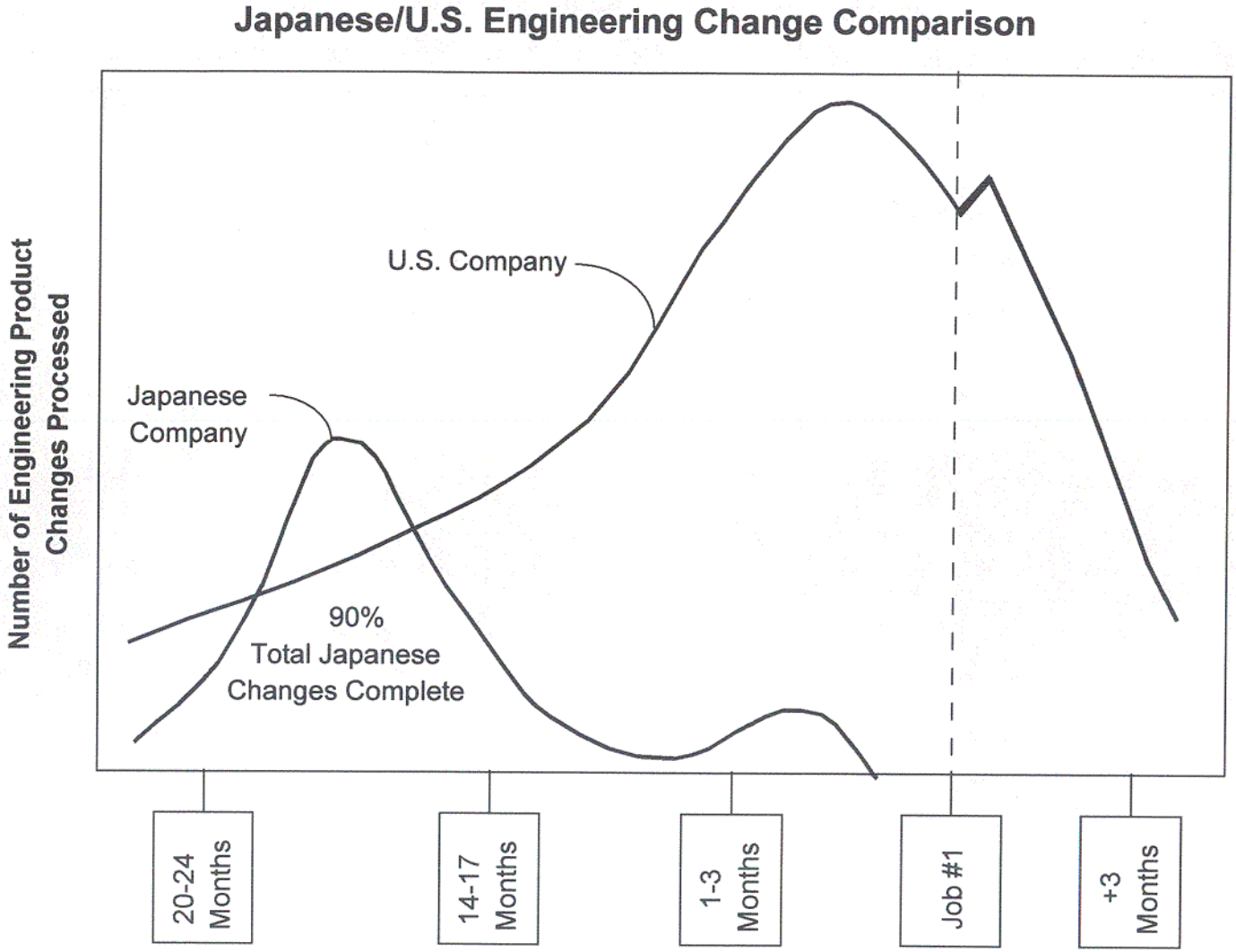
Japanese Auto Industry Made Changes Earlier Than U.S. Auto Industry



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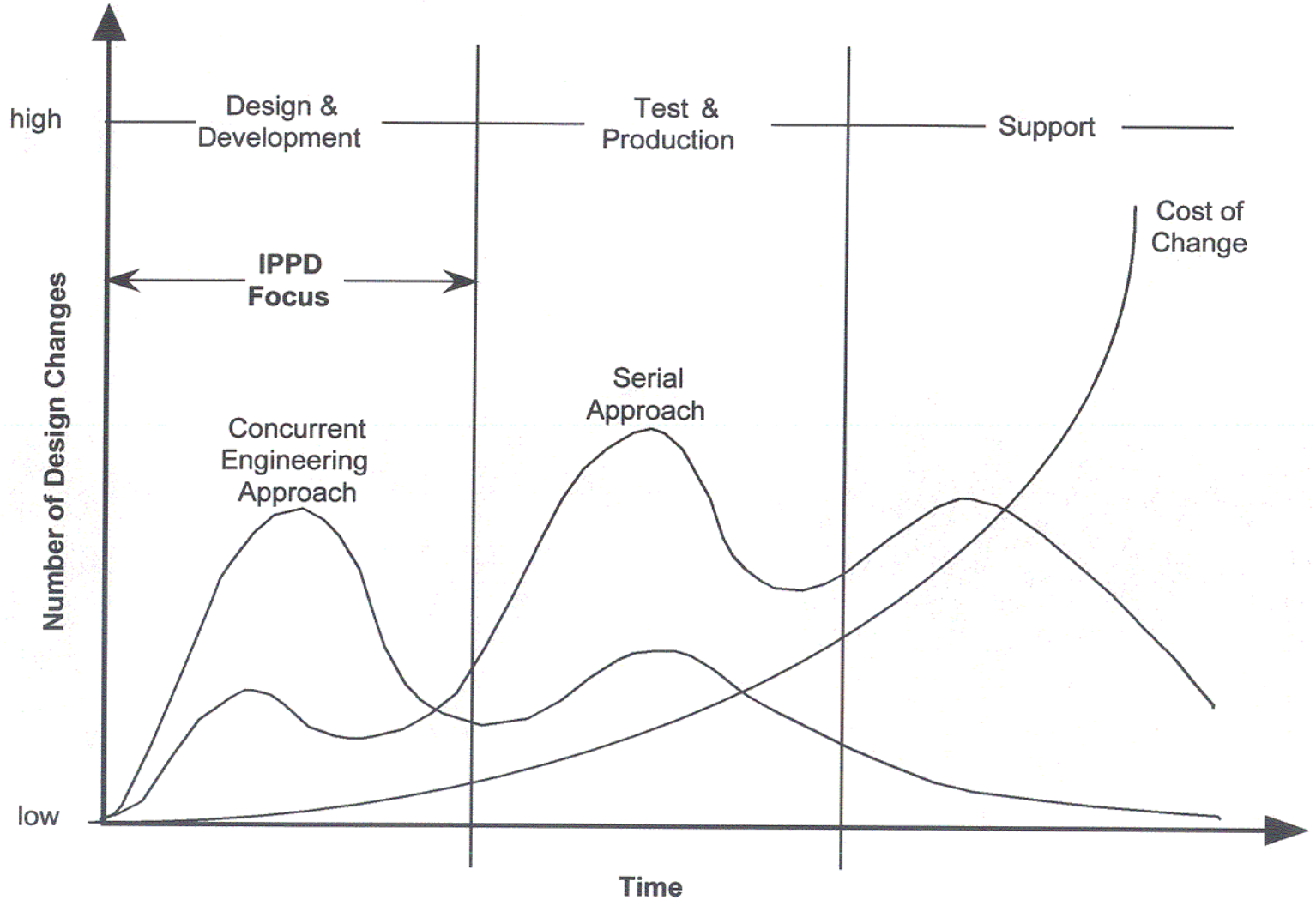
Concurrent vs Serial Approach



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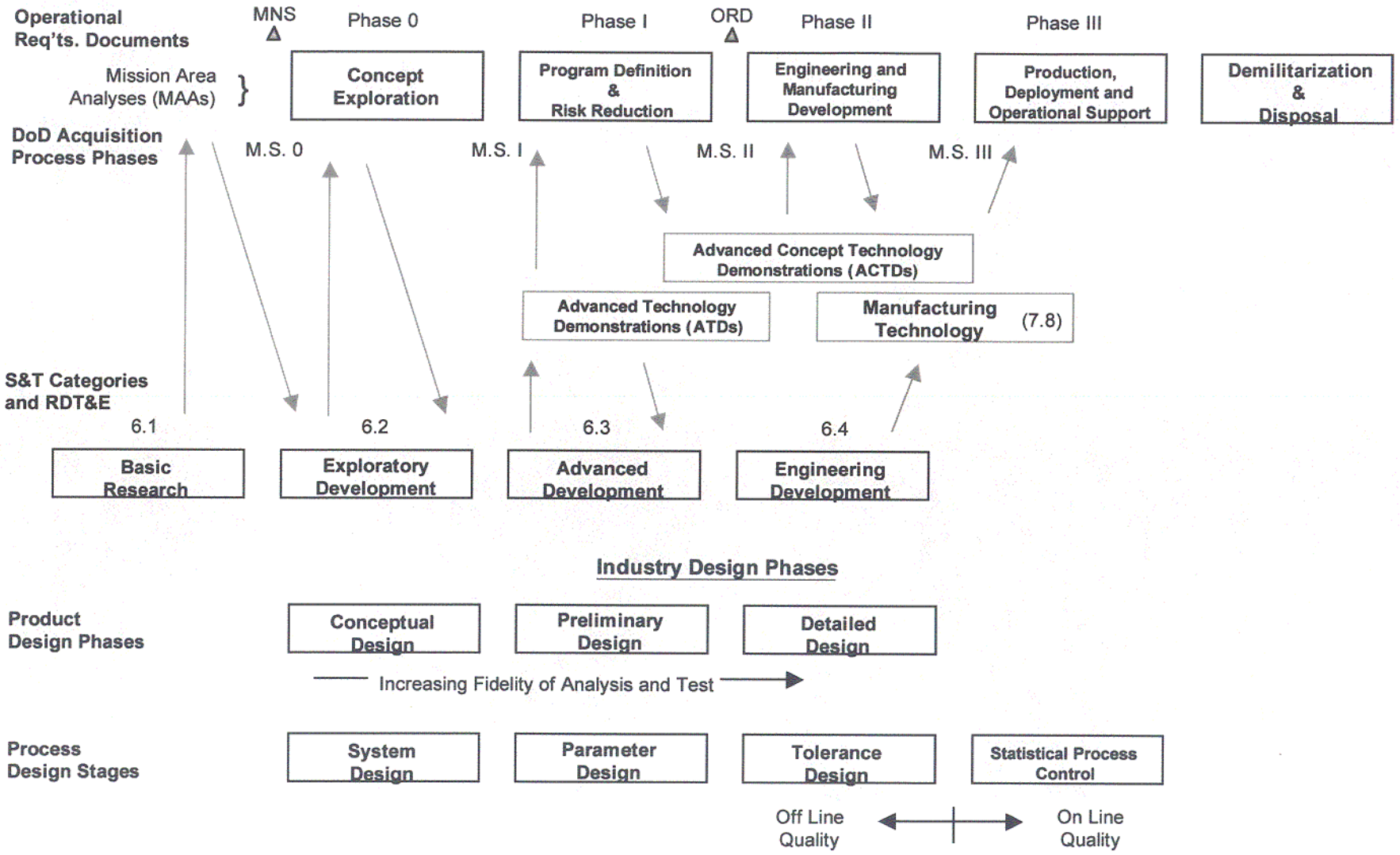
Today's DoD Acquisition Process and Its Interfaces



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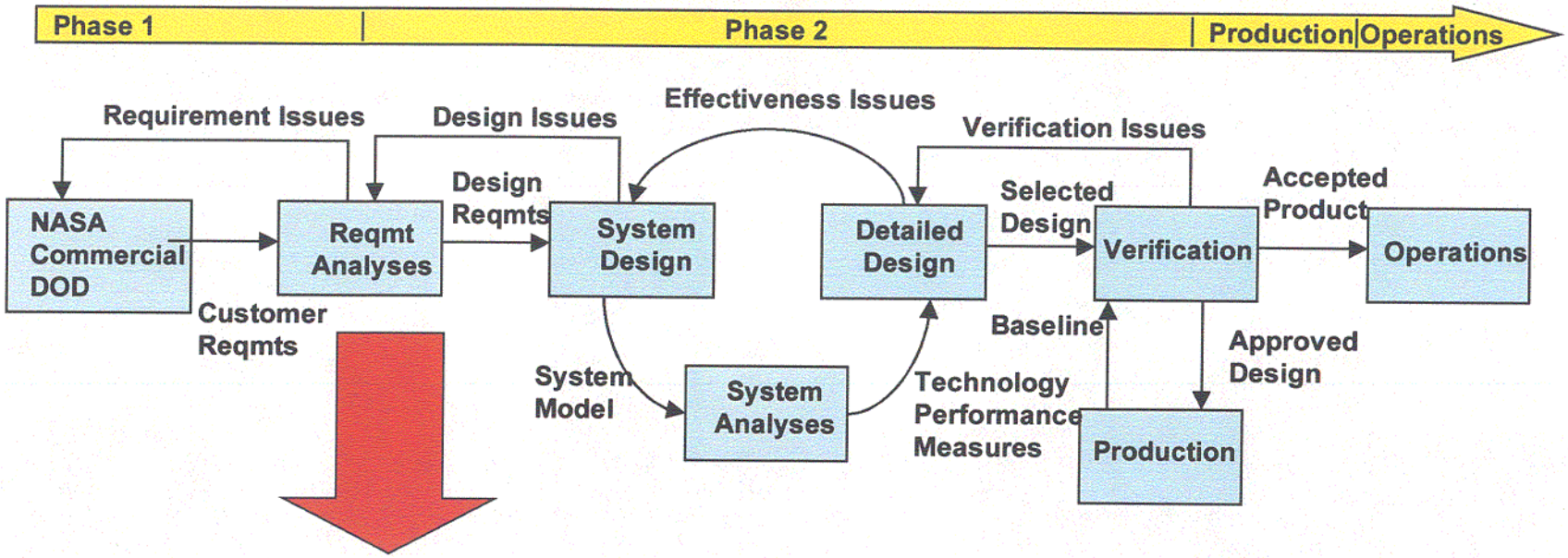
NASA's Life Cycle Process Model
(2nd Generation RLV Risk Reduction Solicitation)



Safety

Reliability

Affordability

Mission Performance

→ Refine for Commercial Convergence → Define Priority Risk Reduction Needs → Define Scale, Fidelity, Test Environment for Tech Demos → Enable Full Scale Development With 20% Margin

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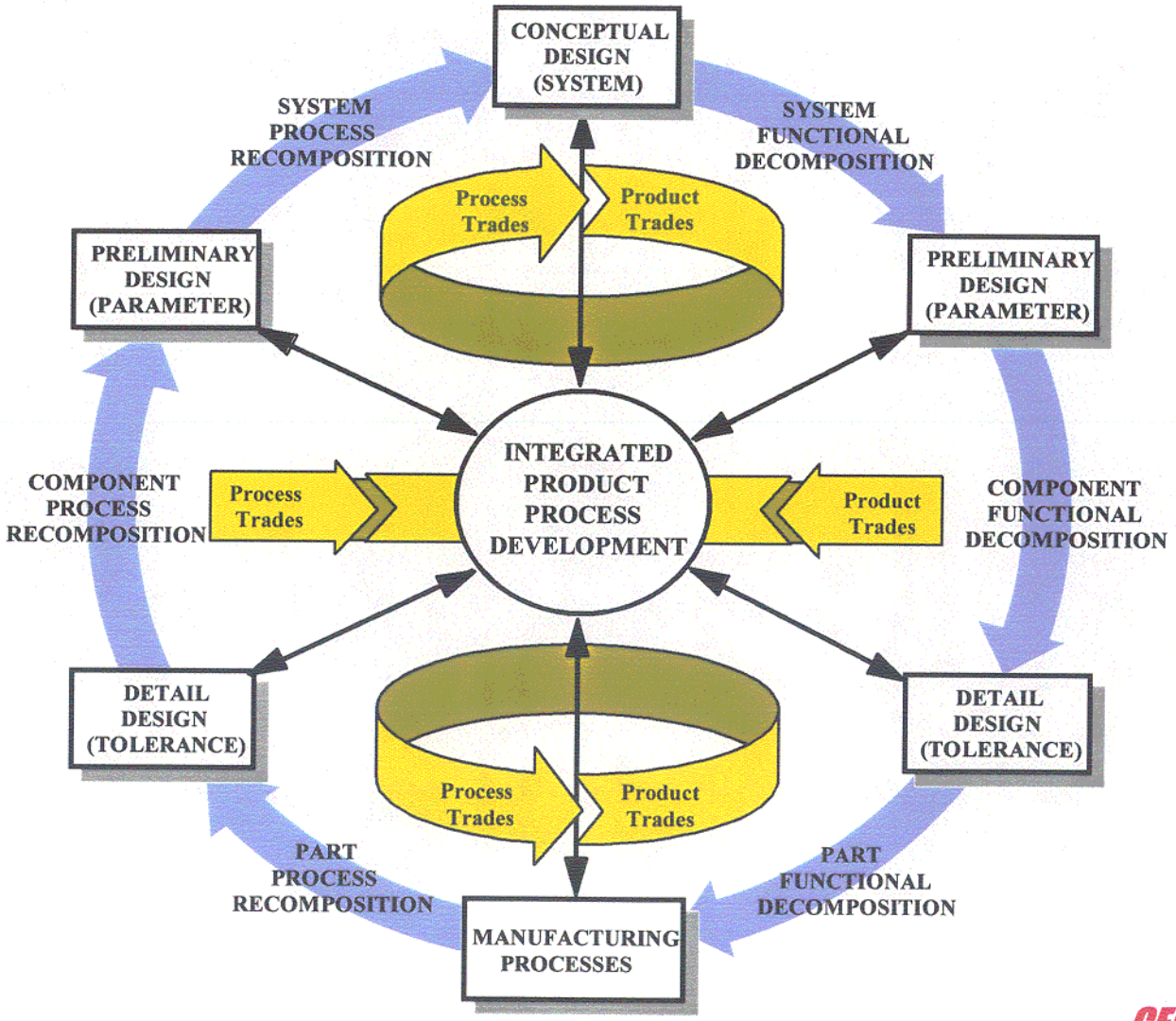
IPPD Requires the Computer Integration of Product and Process Models and Tools for System Level Design Trades and Cycle Time Reduction



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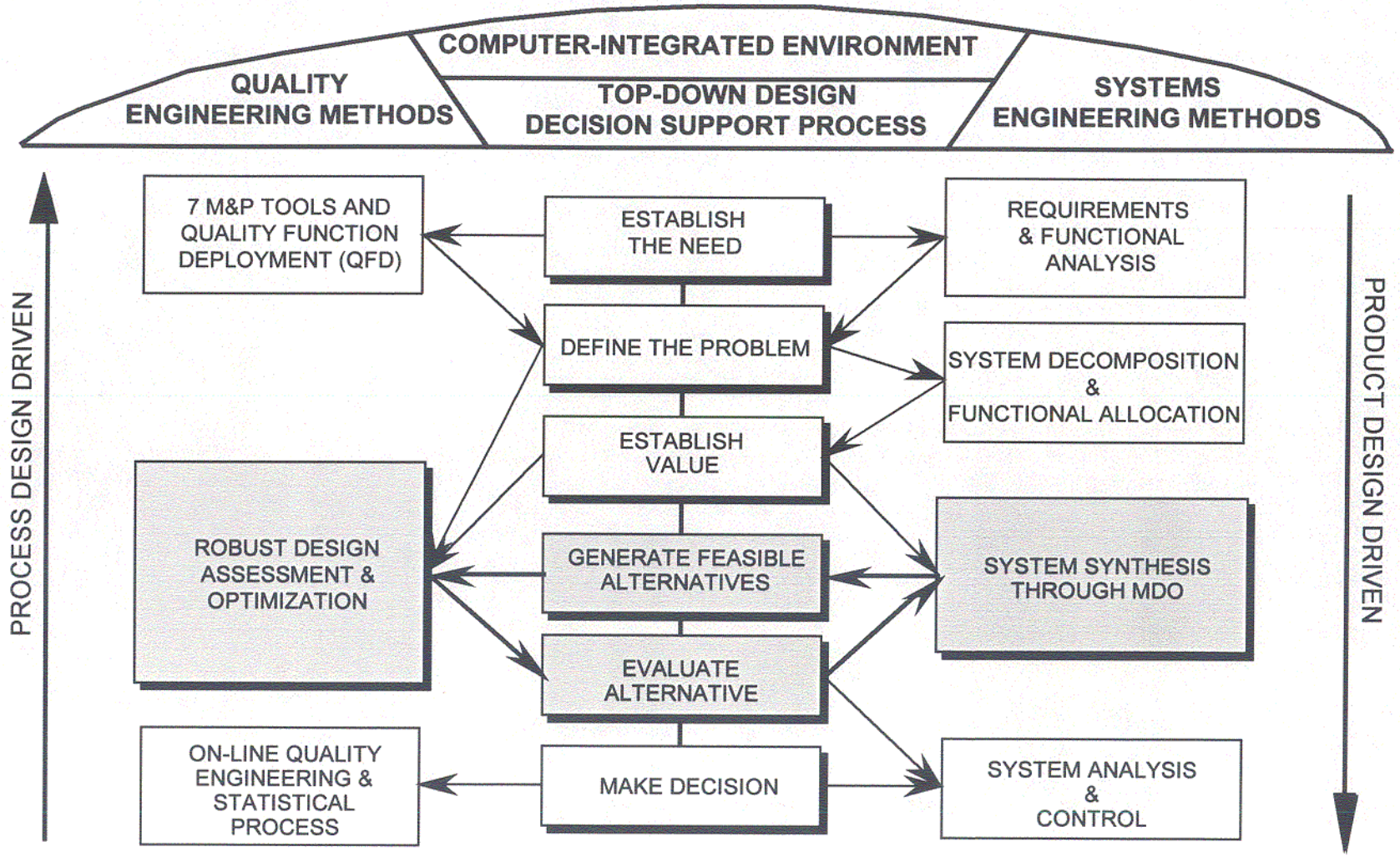
Georgia Tech Generic IPPD Methodology



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Georgia Tech Generic IPPD Methodology

- Methodology provides a *procedural* design (trade-off iteration) approach based on four key elements:
  - *Systems Engineering Methods and Tools* (Product design driven, deterministic, decomposition approaches; MDO is usually based on *analytic* design approach)
  - *Quality Engineering Methods and Tools* (Process design driven, nondeterministic, recomposition approaches; MDO is usually based on *experimental* design approach)
  - *Top Down Design Decision Process* Flow (Provides the design trade-off process)
  - *Computer Integrated Design* Environment(*Information Technology* driven)
- Methodology provides a framework for *conducting* and *researching* systems analysis. *Systems Analysis* is a *scientific process*, or methodology, which can best be described in terms of its salient problem-related elements. The process involves:
  - *Systematic examination and comparison of those alternative actions* which are related to the accomplishment of desired objectives
  - *Comparison of alternatives on the basis of the costs and the benefits* associated with each alternative
  - *Explicit consideration of risk*
- Methodology has been implemented through *Robust Design Simulation (RDS)* for a number of applications

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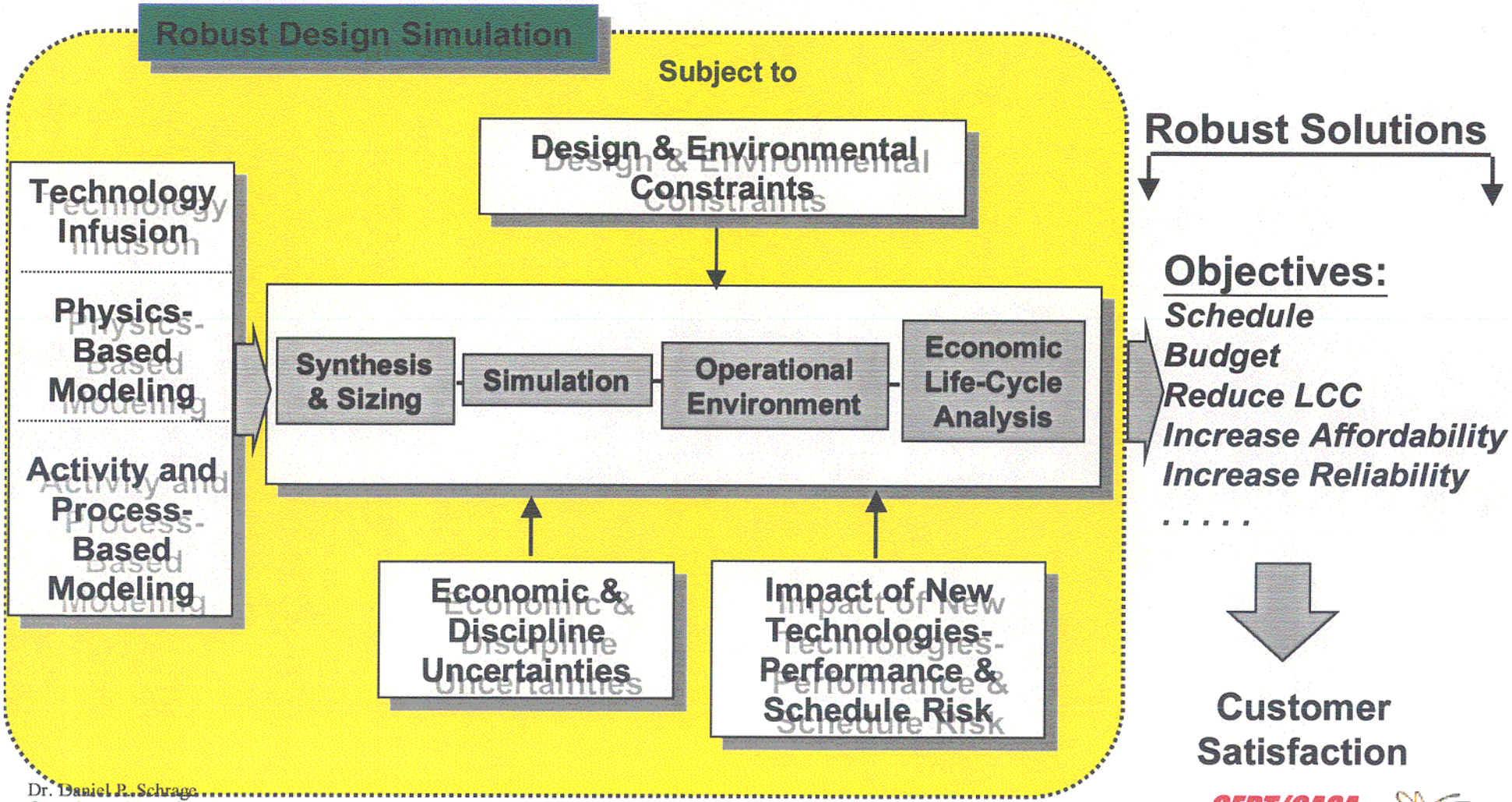
Roadmap to Affordability Through Robust Design Simulation



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What is IPPD Through RDS

- *Integrated Product/Process Development (IPPD) means applying Concurrent Engineering* at the *front end* of a system's life cycle where design freedom can be leveraged and product/process design tradeoffs conducted in parallel at the system, component, and part levels
- Implementation of IPPD requires *moving from a deterministic point design approach to a probabilistic family design approach* to keep the design space open and from committing life cycle cost before the system life cycle design trade-offs can be made
- *Robust Design Simulation (RDS)* provides the necessary simulation and modeling environment for executing IPPD at the *System level*
- Continuation of RDS along the system life cycle implies the creation of a *Virtual Stochastic Life Cycle Design Environment*
- An *Overall Evaluation Criterion (OEC) based on System Affordability* should be identified early and its variability tracked along the life cycle time line

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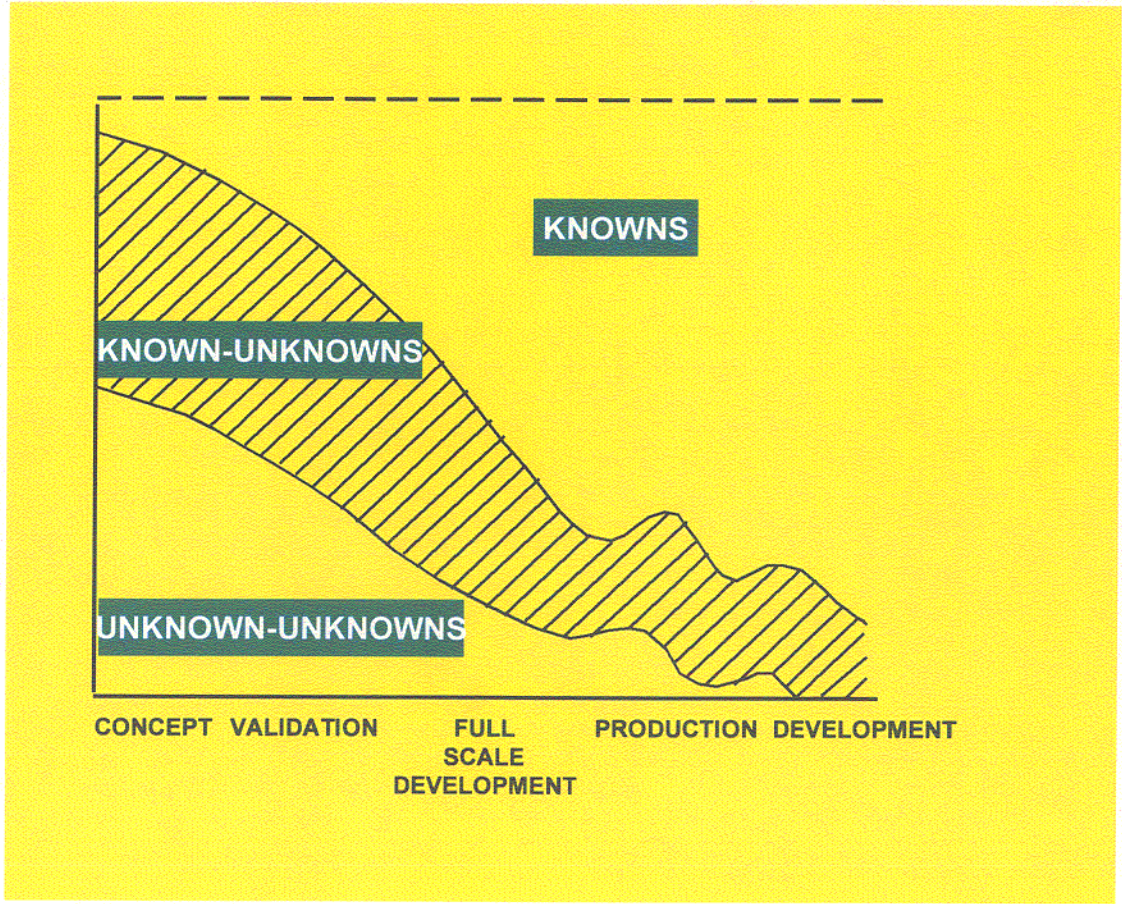
Risk & Uncertainty are Greatest at the Front



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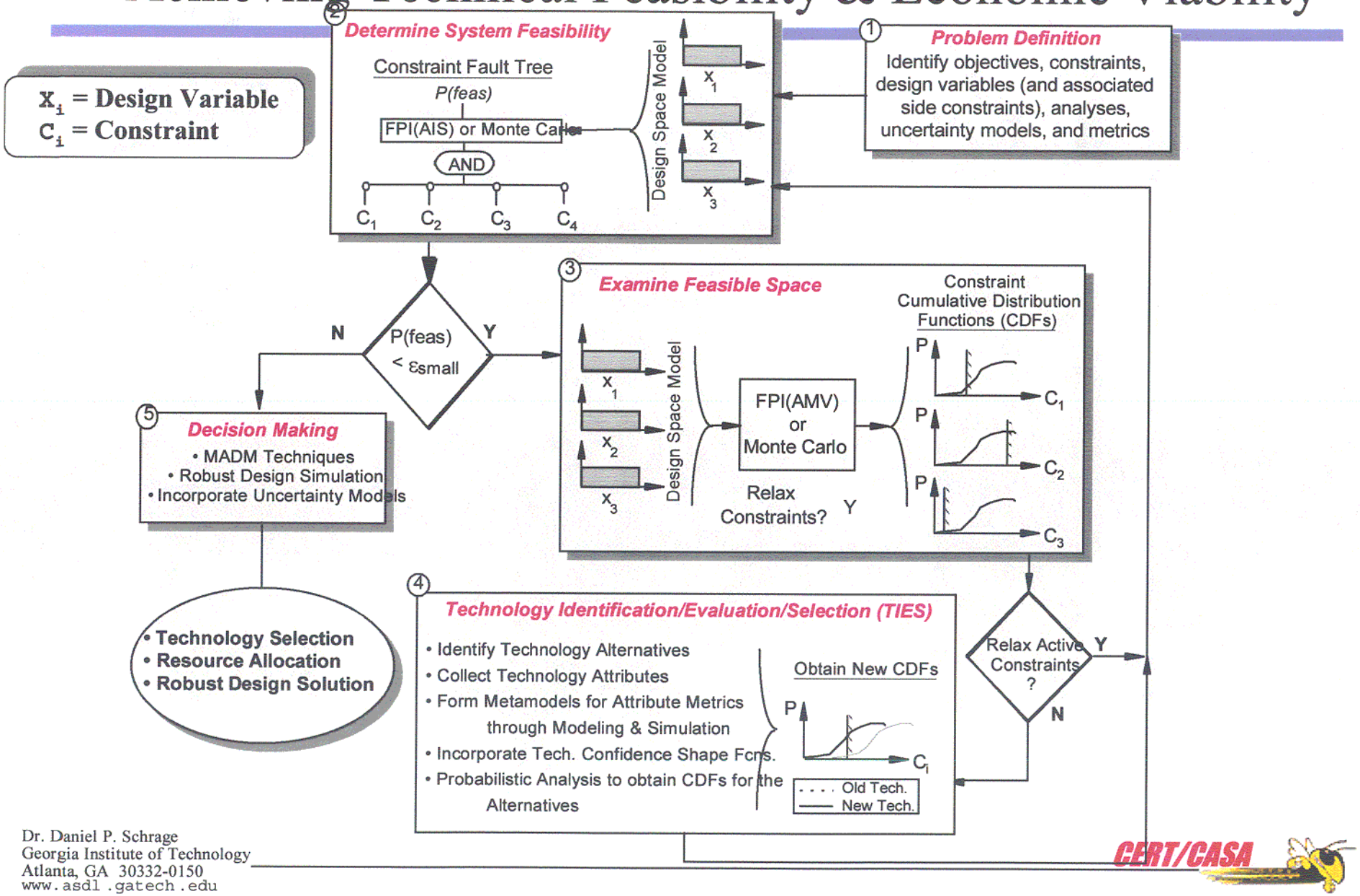
Roadmap to System Affordability
Achieving Technical Feasibility & Economic Viability



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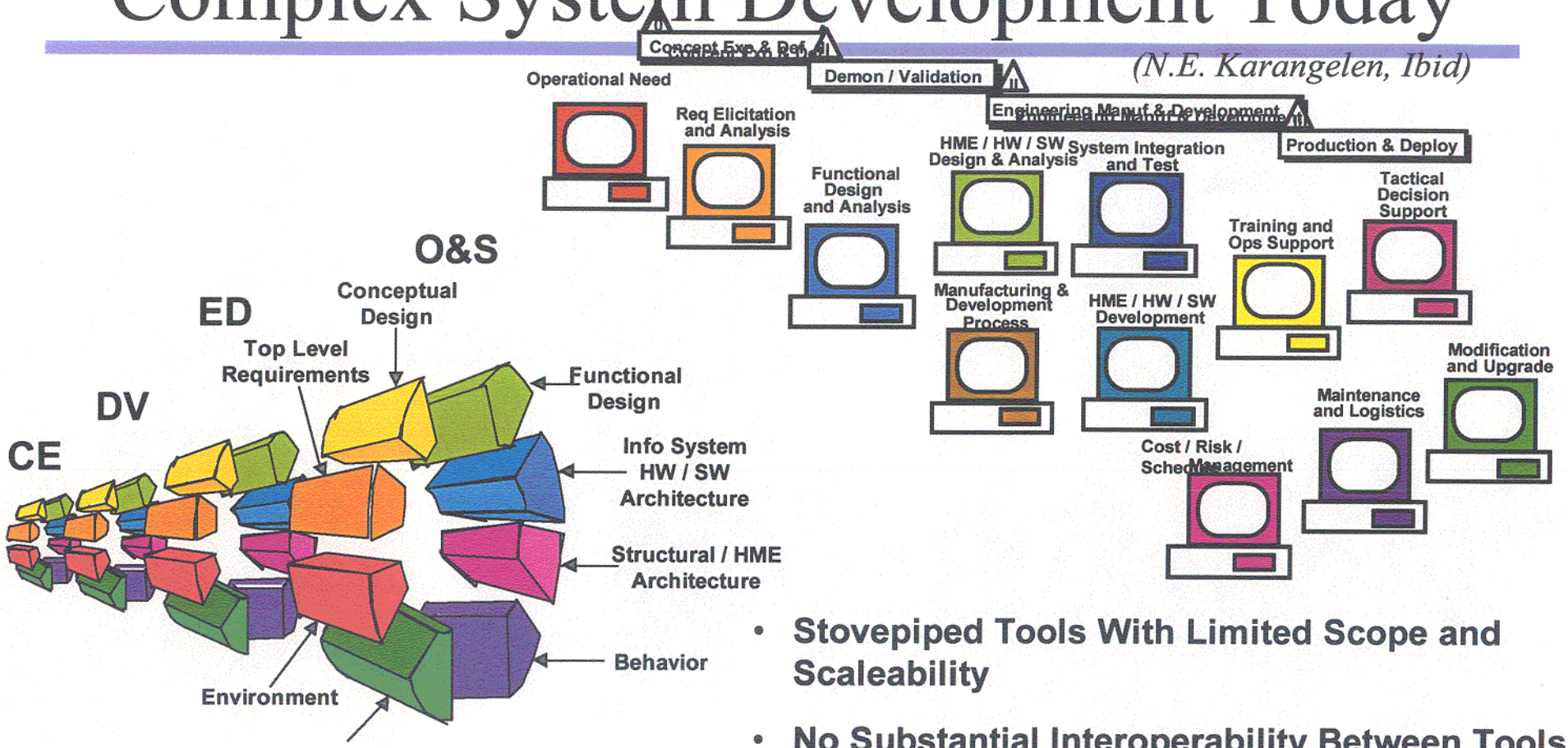
What is SBA?

- The DoD envisions an acquisition process supported by the robust, collaborative use of simulation technology that is integrated across acquisition phases and programs. The objectives of Simulation Based Acquisition (SBA) are to:
  - Reduce the time, resources, and risk associated with the acquisition process
  - Increase the quality, military utility, and supportability of systems developed and fielded
  - *Enable IPPD* from requirements definition and initial concept development through testing, manufacturing, and fielding

  (Sanders, P., "Simulation Based Acquisition", PM: Sep-Oct 1997)
- SBA is being implemented by each of the military services in a different way
- NASA is initiating their version of SBA, called Intelligent Synthesis Environment (ISE)
- The common generic name is Advanced Engineering Environment (AEE) as defined by the National Research Council Study on AEEs

Complex System Development Today

(N.E. Karangelen, Ibid)

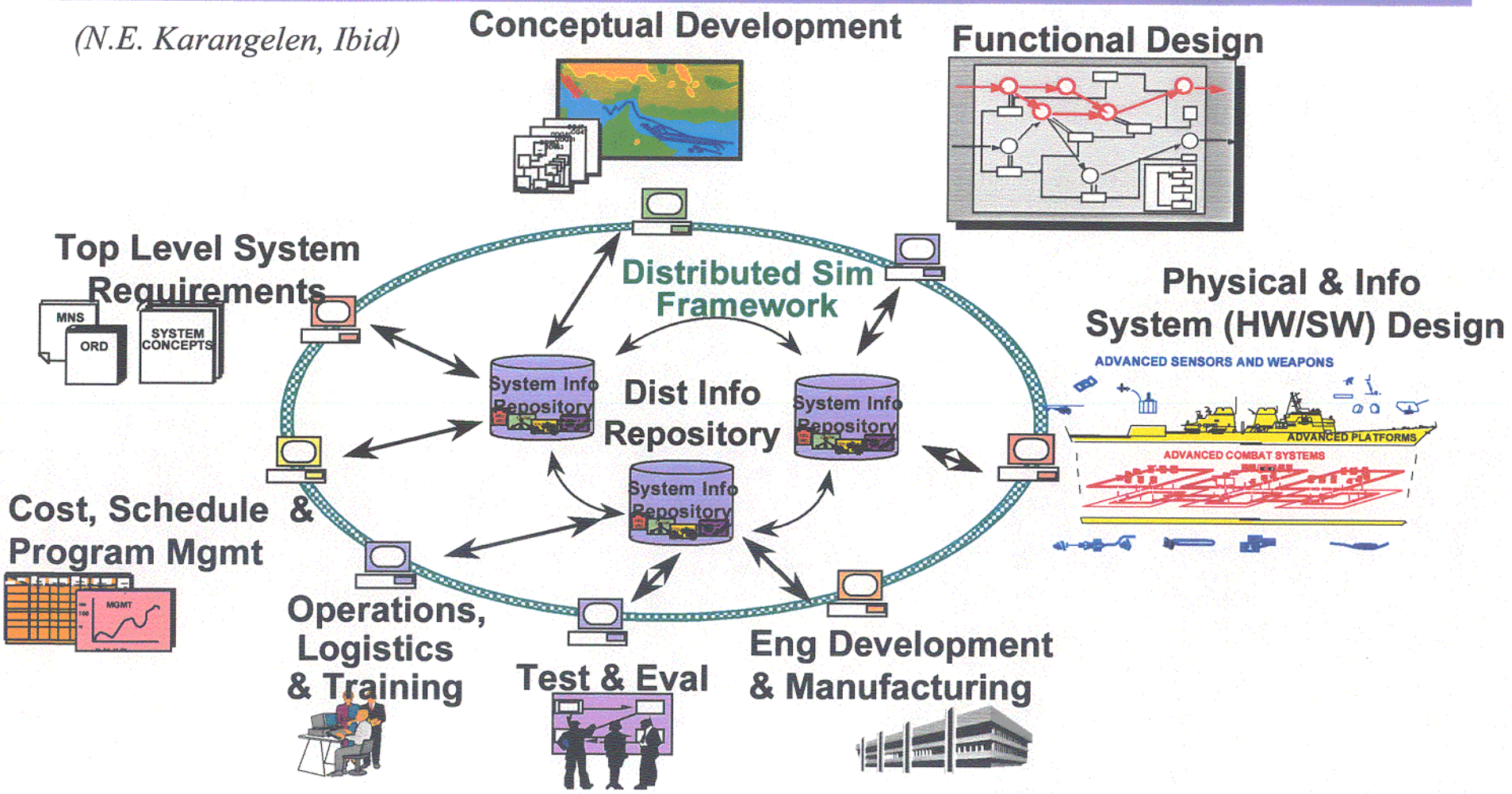


- **Stovepiped Tools With Limited Scope and Scaleability**
- **No Substantial Interoperability Between Tools**
- **Independent Data Bases With Ad Hoc Configuration Management / Traceability**

Today's Development Process Remains Largely Manual and Employs a Single Design Baseline Where Simulation and Assessment Lags the Design

SBA OPERATIONS CONCEPT ILLUSTRATION

(N.E. Karangelen, Ibid)



Capture System Information Once in Common Interoperable Format a
Apply Distributed Tools for Collaborative Assessment and Optimizatic

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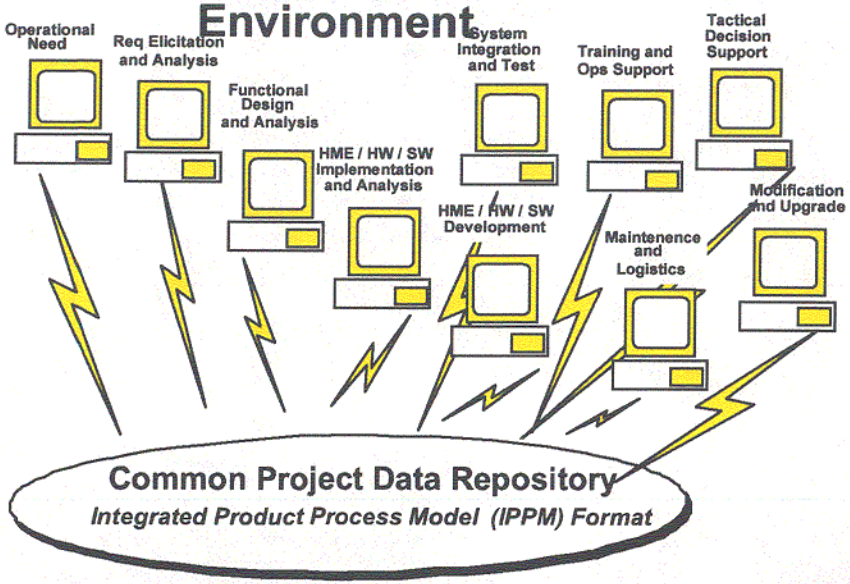
SBA VISION SUMMARY

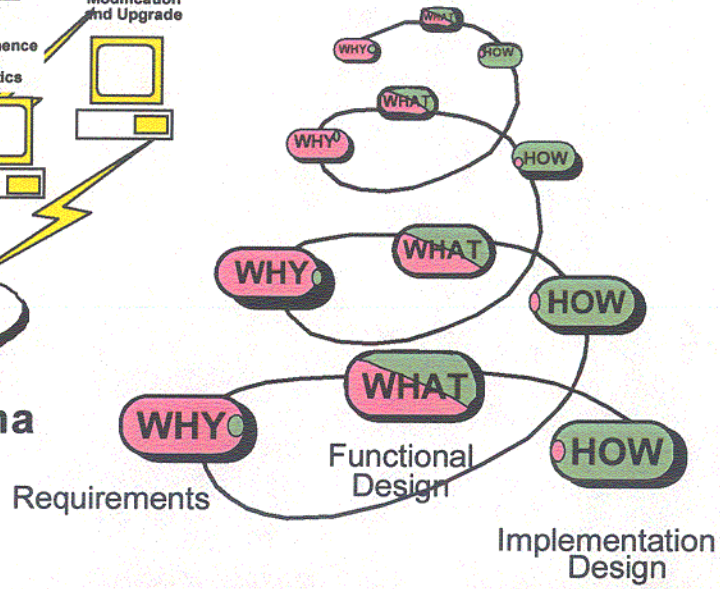
1 Integrated Engineering Environment



- **Integrated Design Data Schema**
- **Dist System Info Repository**
  - User Transparent Web Style Access
- **Collaborative Distributed Engineering**
  - Seamless Integration of Engineering Disciplines

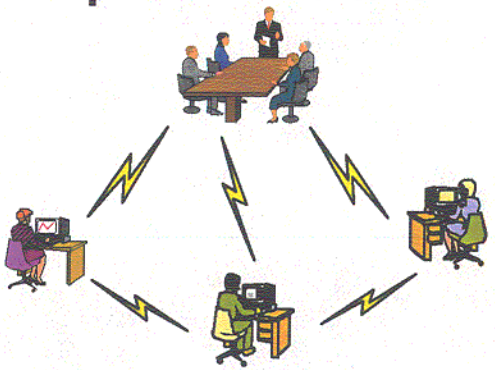
2 Iterative Acquisition Process

(N.E. Karangelen, Ibid)



- **Iterative Spiral Process**
  - Rapid Evaluation of Multiple Options
  - Electronic Exchange of System Models

3 Evolved Acquisition Culture



- **Integrated Process Teams**
  - HME and Info Systems
- **Changing Roles and Responsibilities**
  - Policy and Education
  - Standards and Guidlines

EFFICIENT AUTOMATION / MULTIPLE BASELINES
MULTI-DOMAIN / CONCURRENT SIMULATION CAPABILITIES

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NASA's Intelligent Synthesis Environment

Goal:

"To develop the capability for scientists and engineers to work together in a virtual environment, using simulation to model the complete life-cycle of a product/mission before commitments are made to produce physical products"

Some ISE Attributes:

- Network of geographically distributed engineering and science capabilities for full life-cycle design and analysis of new systems
- Cooperatively linked to other gov't, industry, and university facilities
- Employ traditional, non-traditional and non-deterministic methods
- Intelligent decision making aids

ISE Functional Initiatives:

- Rapid Synthesis and Simulation tools
- Cost and Risk management Technology
- Life-Cycle Integration and Validation
- Collaborative Engineering Environment
- Revolutionize Cultural Change, Training and Education

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What is an AEE?

- Implementations of computational and communications systems
- Integrated virtual and distributed environments
- Linking researchers, technologists, designers, manufacturers, suppliers, and customers
- Mission-oriented, leading-edge engineering teams
- Industry, government, and academia

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Evolution of Georgia Tech's Aerospace Systems Design Program

'84 - Graduate Rotorcraft Design Program Established
'89 - *Intro to Concurrent Engineering* (CE) & *Design for LCC* courses
'92 - Graduate, CE/IPPD Fixed-Wing Design Program Established w/ NASA's USRA

Graduate Program Development

'94- NASA MDA Fellowship Grant and New Approaches to MDO Grant

'95-'96 Space Systems Design Laboratory (SSDL) Established

'96- NRTC Center of Excellence Renewal (including *IPPD for Affordable Rotorcraft* Task)

'98- Center for Aerospace Systems Analysis (CASA) Initiated

'99- *Boeing* Awards Faculty Chair in Aerospace Systems Analysis to GTAE/CASA

'94 CE/IPPD — Focus: Affordable Aerospace Systems Design Methodology

'95 RSM for Advanced Synthesis — Focus: Pioneering Research into Response Surface Methodology (RSM) for advanced sizing/synthesis

'96 RDS — Focus: Addressing Economic Uncertainty & Viability results in Robust Design Simulation

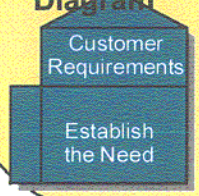
'97 TIF — Focus: Tech. Impact Forecast & Probabilistic Analysis thru Fast Probability Integration (FPI)

'98 TIES — Focus: The effects of technologies on Affordability via Technology Identification, Evaluation, Selection (TIES) method

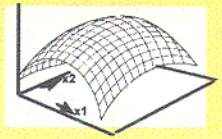
Aero + Structures

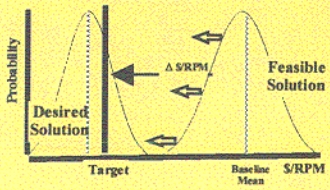
Probabilistic Feasibility AND Viability

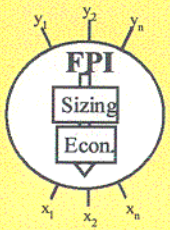
Morphological Matrices • Push Diagram



FLOPS-IMAGE-RSE Interface developed







Virtual Stochastic Life Cycle Design Environment

2000.... VSLCDE

CERT/CASE
CASA:
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The VSLCDE- Key Characteristics

The purpose of VSLCDE is to facilitate design decision-making over time (at any level of the organization) in the presence of uncertainty, allowing affordable solutions to be reached with adequate confidence. It is a research testbed.

- ***Virtual*** . . . Simulation-based system life-cycle prediction
- ***Stochastic*** . . . Time-varying uncertainty is modeled; temporal decision-making
- ***Life-Cycle*** . . . the design, engineering development, test, manufacture, flight test, operational simulation, sustainment, and retirement of a system. The operational simulation includes virtual testing, evaluation, certification, and fielding of a vehicle in the existing infrastructure, and tracking of its impact on the economy, market demands, environment.
- ***Design*** . . . Implies that the environment's main role is to provide knowledge for use by decision-makers, especially for finding robust solutions
- ***Environment*** . . . Implies the support of geographically distributed analyses and people through collaboration tools and data management techniques

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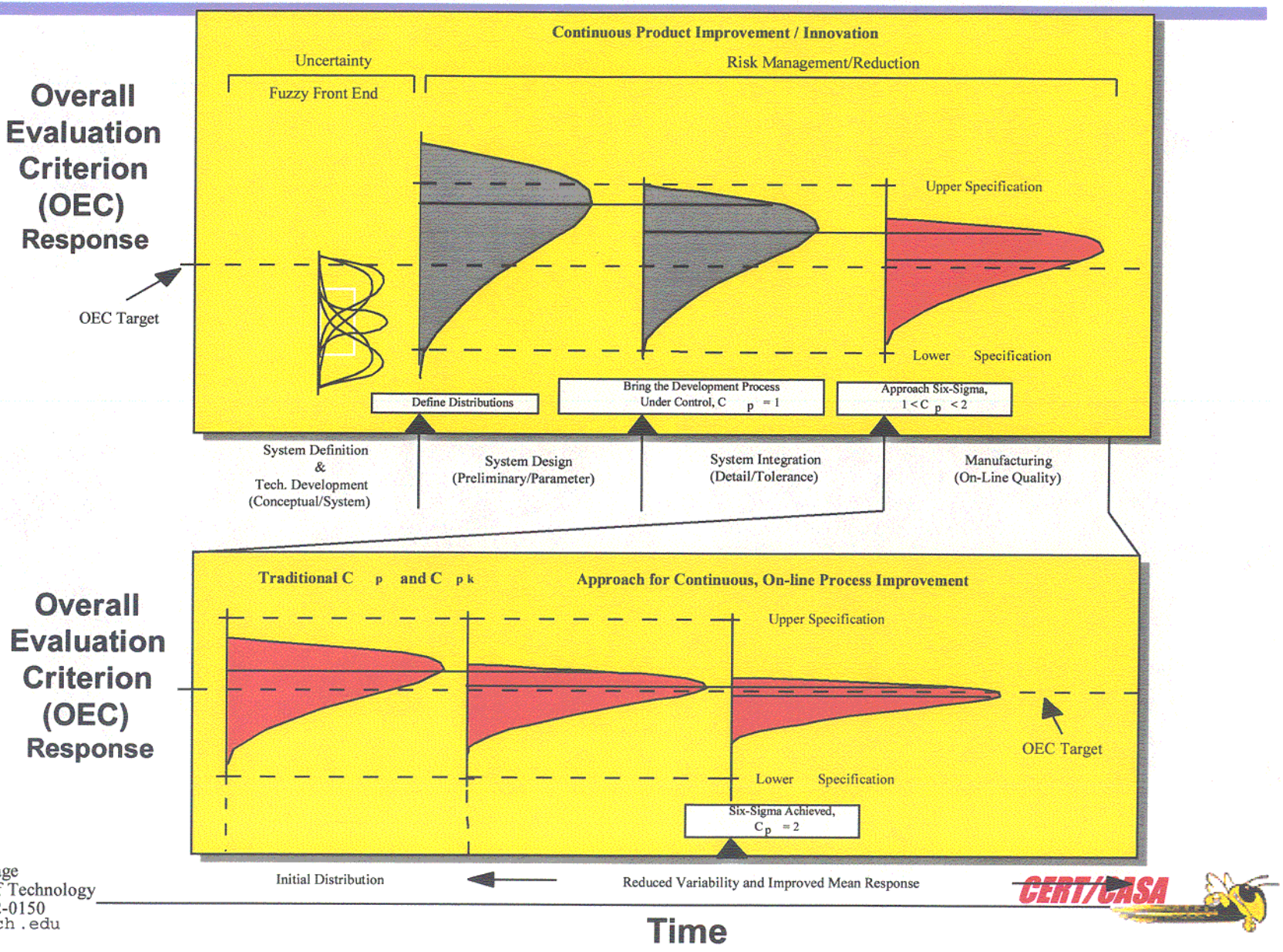
Coninuous RDS along the System Life Cycle to link the "fuzzy front end" to the "process capability approaches"



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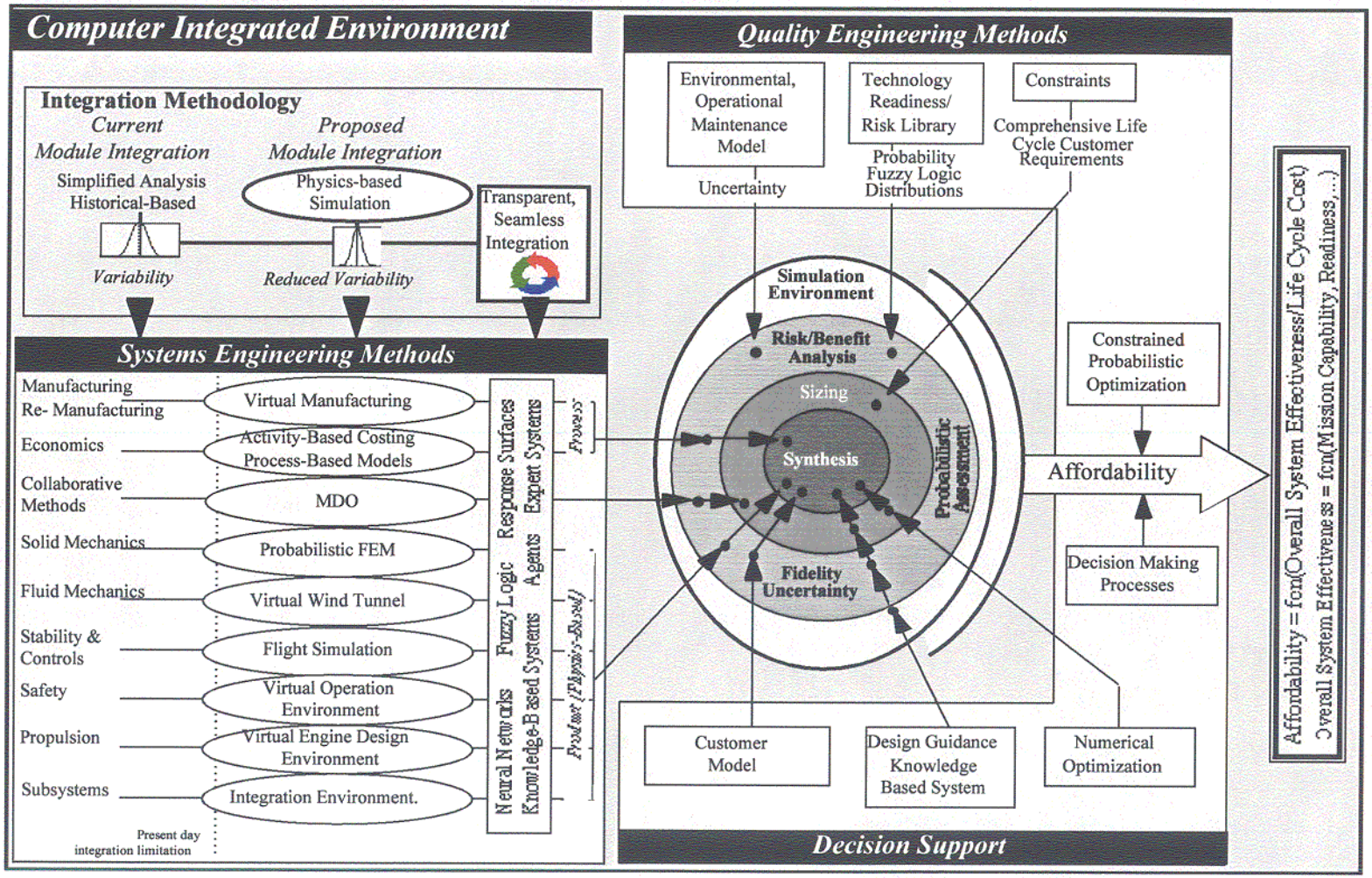
CASA Vision of a Virtual Stochastic Life Cycle Design Environment (VSLCDE)



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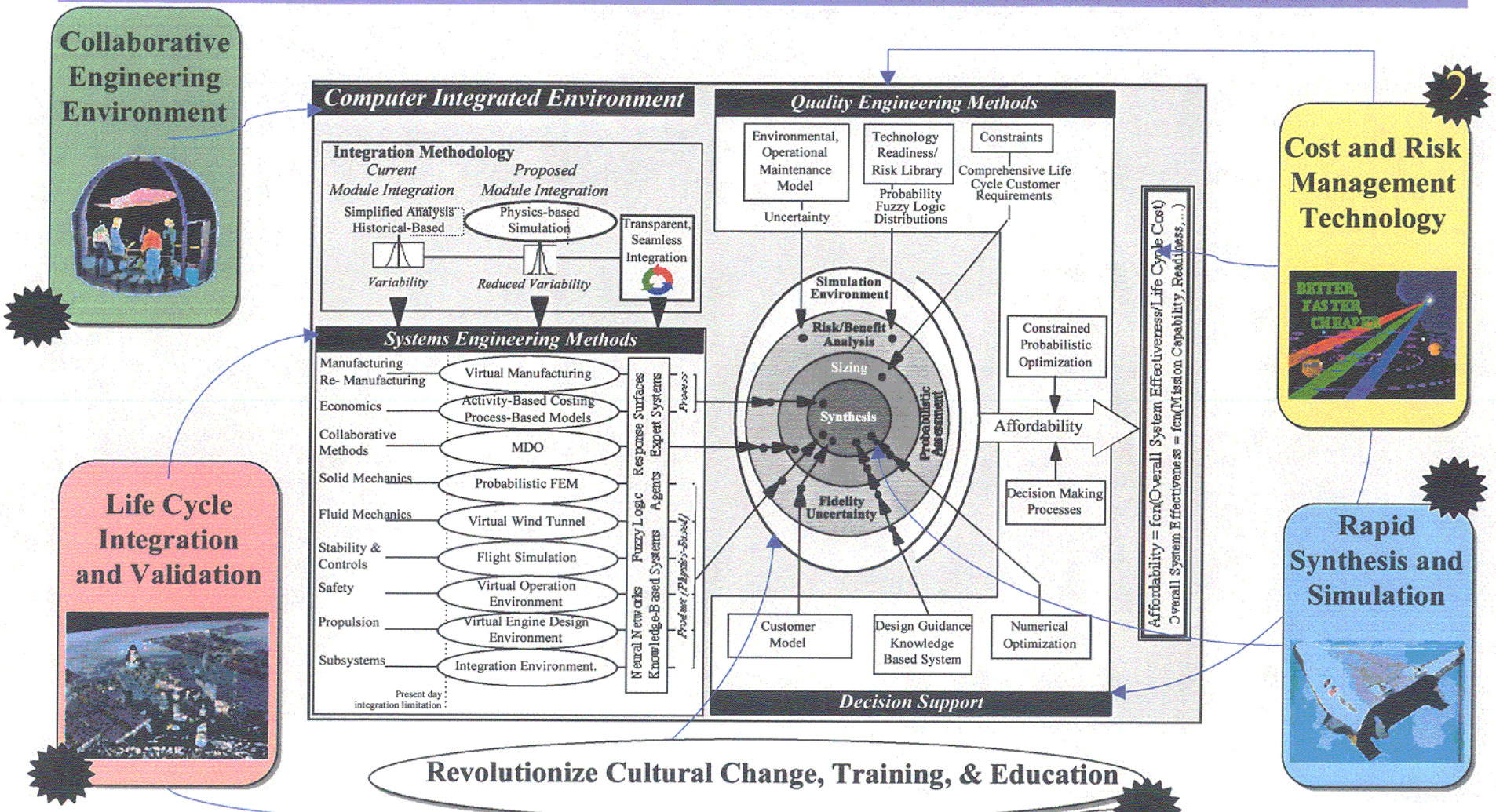
Relation of *VSLCDE* to 5 *ISE* Initiatives-

A Prototype and Research Test-Bed



The Role of CASA

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Summary and Conclusions

- A clear understanding of IPPD and what it entails is the starting point for SBA
- RDS is the environment required today for the execution of SBA
- The future environment has been identified in the NRC AEE Report: *Design in the New Millenium*
- The Georgia Tech CASA is conducting research to provide its version of an AEE, called VSLCDE

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